CMWR 2008 STUDENT FELLOW AWARDEE

Name:	Manav Tyagi
Institution:	ETH Zurich, Institute of Fluid Dynamics
Email address	tyagi@ifd.mavt.ethz.ch

TITLE: **A Stochastic-Lagrangian Model for Multiphase Flow in Porous Media: Upscaling of Non-Equilibrium Pore Scale Dynamics**

ABSTRACT:

CO_2 storage in subsurface formations involves many complex physical processes that are well understood at the pore scale. However, in a real scenarios, it is not feasible to perform pore scale simulations, and one needs a large scale model. Unfortunately, the Darcy based large scale models for multiphase flow and transport are questionable, particularly in the context of CO_2 storage. One of the main assumptions in these models is the concept of relative permeability and capillary pressure, which are expressed as functions of saturation. Moreover, these quantities are typically measured under equilibrium conditions and scale independence is assumed. However, under unstable conditions these assumptions may not be valid. We proposed [1] an alternative modeling approach based on the Lagrangian movement of stochastic particles, which represent infinitesimal fluid phase volumes and evolve such that their statistics represent the statistics of the actual fluid volumes. Each particle is labeled by a fluid phase, has its individual velocity, a position in physical space and possibly other properties, e.g. CO_2 concentration. As a particle moves in physical space, its properties change according to the stochastic processes such that the specified Lagrangian statistics is honored.

The goal of this work is to model these stochastic processes based on the pore scale physics. For the illustration purpose a simplified 3D pore-network consisting of spherical pores and cylindrical throats is considered. The flow through the network is described by simple rules for the fluid movement in the throats and for the pore filling [2]. First, flow with self-similar average saturation profiles are investigated. These cases correspond to multiphase Darcy flow, where the relative permeabilities are uniquely determined by the saturation values. More interesting are those scenarios, where no self-similar profile can observed and classical multiphase Darcy model fails. For such cases non-equilibrium phenomena at the pore scale play an important role and we demonstrate how these can be modeled in our stochastic particle framework. With the help of pore-network simulations first the non-equilibrium pore scale dynamics has been studied. Then, based on the extracted Lagrangian statistics, comparative simulations with stochastic particle method have been performed.

References:

1. M. Tyagi, P. Jenny, I. Lunati, H. A. Tchelepi, 2006, Multiscale method for multiphase flow in porous media using stochastic particles, CMWR XVI , 19-22 June 2006, Copenhagen, Denmark.
2. R. Lenormand, E. Touboul, and C. Zarcone, 1988 Numerical models and experiments on immiscible displacements in porous media, *J. Fluid Mech.* 189, 165-187.